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RAND GULF STATES POLICY INSTITUTE

Strengthening Coastal Planning

How Coastal Regions Could Benefit from Louisiana's Planning and Analysis Framework

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This volume was prepared as part of the RAND-Initiated Research program and was funded by the generosity of RAND's donors and by fees earned on client-funded research.

Library of Congress Control Number: 2014933035

ISBN: 978-0-8330-8455-2

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Cover image: The Inner Harbor Navigation Canal Surge Barrier, developed by the U.S. Army Corps of Engineers after the 2005 hurricane season and completed in 2011, is designed to reduce the risk of storm surge flooding to many parts of New Orleans. It is located to the east of New Orleans and is currently the largest such barrier in the United States. (USACE photo by Paul Floro.)

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Summary

According to the U.S. Census Bureau, the populations of U.S. coastal counties have grown by more than 45 percent between 1970 and 2010, amounting to 50 million new coastal residents and billions of dollars in additional assets (homes and businesses) in these areas. Coastal residents are vulnerable to many potential risks, including damage to human life and property that results from storm flooding. The increasing concentration of people, property, and other activities in coastal areas can itself contribute to the problem by removing or diminishing wetlands, barrier islands, and other features that serve as natural buffers to storm surges.

The Gulf Coast has borne a substantial portion of the damage from coastal storms in recent decades. For example, in 2005 more than 1,880 people died and thousands more were displaced or left with conditions that compromised their safety, health, and economic well-being due to Hurricane Katrina. Direct damage to New Orleans residences alone is estimated to have reached between \$8 billion and \$10 billion. But these coastal risks are also prevalent in other areas, as shown by the massive damage and disruption that Hurricane Sandy caused to the people, homes, businesses, and infrastructure of coastal communities along the Eastern Seaboard.

Coastal risks may increase as the climate warms. Sea levels are anywhere from six to 12 inches higher now than a century ago and continue to rise at a rate of more than an inch per decade. Current projections suggest that the rate of sea-level rise will continue to increase because of warming oceans and melting glaciers, leading to sea levels from 8 inches to as much as 4–6 feet higher than 1990 levels by 2100. Such increases, when combined with coastal tides and storm surge, will likely dramatically increase the risk of floods to coastal residents and property. Additionally, warming sea surface temperatures and changing climate patterns could also either intensify future tropical storms and hurricanes or make large and powerful hurricanes more common.

Reducing the vulnerability of coastal communities to these threats is challenging, given both the scale of the problem across broad geographic regions and uncertainty about the specific nature of the risk. Several restoration efforts in the United States have begun to take more-comprehensive planning approaches to addressing such challenges. Those in the Everglades, Chesapeake Bay, and the San Francisco Bay Delta regions are notable recent examples. But such efforts have not yet led to a broadly applicable methodology for identifying and reducing coastal vulnerabilities to climate change.

Although the challenges that coastal Louisiana faces are not unique, the region is a prime example of the need to address coastal planning challenges in a comprehensive way. In Louisiana, storm-surge flood-risk challenges are exacerbated by the loss of land brought on by how the Mississippi River was managed during the past century. Coastal Louisiana is on an unstable path of ongoing land loss. Since the 1930s, nearly 1,900 square miles of land have been

lost to open water, and more will be lost in the next 50 years (Couvillion et al., 2011). Spurred on by the devastating effects of hurricanes Katrina and Rita in 2005, the State of Louisiana, through its Coastal Protection and Restoration Authority (CPRA), decided to simultaneously and systematically address both coastal flood risk and ongoing coastal wetland loss by developing Louisiana's Comprehensive Master Plan for a Sustainable Coast.

This Master Plan defines a set of coastal *risk-reduction projects* (both structural projects, including levees, and nonstructural projects that reduce flood damage to residential and commercial structures by, for example, elevating structures) and *restoration projects* (such as bank stabilization, sediment diversions, and barrier island restoration) to be implemented over the next 50 years to reduce hurricane flood risk to coastal communities and to restore the Louisiana coast.

A Framework and Planning Tool to Support Development of the Master Plan

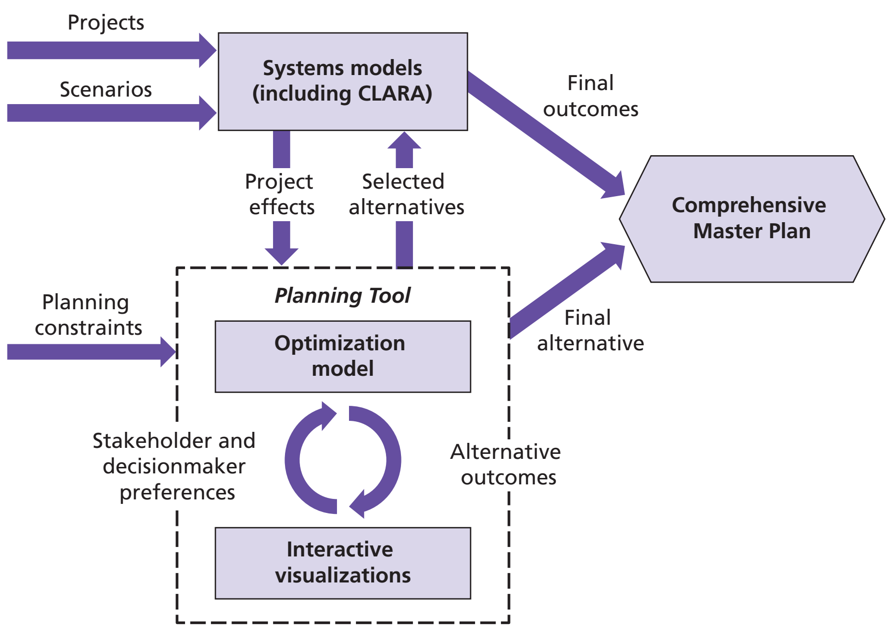
Given the large number of potential projects, the range of stakeholders with competing interests and objectives, and the significant and deep uncertainties to be considered, CPRA asked RAND to support the development of the Master Plan by helping to develop an analytic approach to identify a comprehensive strategy of investments in risk-reduction and restoration projects to address the coast's problems. Part of this mandate was to develop a process that was as objective and transparent as possible and based on the best-available scientific information about coastal processes and flood risk.

Figure S.1 provides a simplified flow chart showing the overall approach. The approach starts by applying a suite of seven interconnected *systems models* to estimate the effects that hundreds of proposed projects could have over the next 50 years on expected flood damage, land building or land loss, and ecosystem services. RAND developed one of these models, the Coastal Louisiana Risk Assessment (CLARA) model, which was used to estimate flood depths and damage that would occur from major storms with and without new risk-reduction investments. The systems models evaluated the effects of each project for two future scenarios that reflect different assumptions about future sea-level rise, the rates at which coastal land subsides (through sediment compaction and other processes), and other key uncertainties about the future: a *moderate* one that assumes low to moderate sea-level rise and subsidence rates, and a *less optimistic* one that assumes much higher values for each. The estimated project effects serve as inputs into the Planning Tool to identify potential alternatives (groups of projects) that could make up the 50-year Master Plan. The Planning Tool uses an optimization model to identify alternatives comprised of risk-reduction projects selected to minimize coast-wide risk to economic assets and restoration projects selected to maximize coast-wide land building, subject to planning constraints related to available future funding, sediment availability, Mississippi River flows, and preferences over a broad range of other outcomes.

The Master Plan Delivery Team[1] used the Planning Tool to formulate hundreds of potential alternatives based on project effects and on the preferences of CPRA senior management and a 33-member stakeholder group consisting of representatives from business and industry; federal, state, and local governments; nongovernmental organizations; and coastal institutions.

[1] The Master Plan Delivery Team was comprised of CPRA staff, a consulting team including RAND researchers, university researchers, and representatives from the U.S. Army Corps of Engineers and U.S. Geological Survey.

Figure S.1
Planning Framework Used in Developing the Louisiana 2012 Master Plan



SOURCE: Groves, Fischbach, Knopman, et al., 2013.
RAND *RR437-S.1*

A key part of the Planning Tool, as shown in Figure S.1, is a set of interactive visualizations that present estimates of how alternatives would or would not achieve CPRA's goals. These visualizations allowed CPRA and stakeholders to review and understand the trade-offs among the alternatives during the deliberation process. For example, the Planning Tool enabled stakeholders and decisionmakers to change different input variables—such as the environmental scenario, preferences for ecosystem service outcomes, and specific funding constraints—to understand the effects of these changes on key outputs of interest, such as damage reduction or land building over time.

The Planning Tool was used to identify a final alternative that struck an acceptable balance of investments across different types of projects, coastal regions, near-term and long-term risk reduction and land-building benefits, and projected future ecosystem services. This group of projects was then reevaluated together using the systems models to better understand synergies or trade-offs among the selected projects.

Evaluating Different Risk-Reduction Strategies

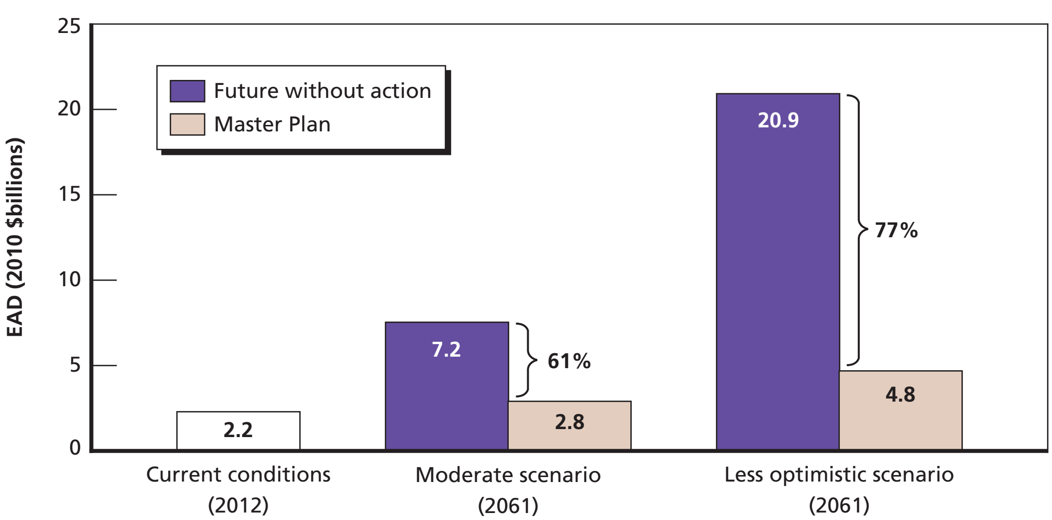
Deep uncertainty was a key characteristic of the decisions Louisiana planners faced when developing the Master Plan. In particular, how would the chosen Master Plan perform in terms of risk reduction in either of the two scenarios (with different assumptions about sea-level rise and other uncertainties) 50 years in the future?

As shown in Figure S.1, a suite of systems models was used to evaluate the effects of different projects on the coast over different scenarios reflecting uncertainty. One of those was the CLARA model, used to estimate flood depths and damage that occur as a result of major storms. CLARA made it possible to systematically evaluate potential projects for the Master Plan based on how well they reduce storm-surge flood damage in Louisiana's coastal region. The results from CLARA show that, without the Master Plan's protection and restoration projects, storm-surge flood damage represents a major threat to coastal Louisiana. All told, CLARA includes a level of detail suitable for rigorously performing comparative evaluations of many options while accounting for a wide range of future uncertainties, including those emerging from a changing climate. Beyond its help in developing the current Master Plan, CLARA can also serve as a road map for future evaluations of coastal flood damage or damage reduction in Louisiana and other coastal regions.

Flood-damage results developed with CLARA show that storm-surge flood damage represents a major threat to coastal Louisiana and that, if no action is taken, this damage can be expected to grow significantly in the future (Figure S.2). The increase in flood damage, however, varies substantially across the two scenarios considered in the 2012 Master Plan. These scenarios differed across many uncertain factors, including sea-level rise, subsidence, and storm frequency and intensity. For instance, in 2061, expected annual damage (EAD) is projected to increase to between $7 billion and $21 billion without action, depending on whether the scenario included moderate, middle-of-the-road assumptions or whether the scenario included less optimistic assumptions (purple bars). But, with the Master Plan in place, this damage level is reduced to between $3 billion and $5 billion for the two scenarios (beige bars). This corresponds to a reduction of approximately 60 percent to almost 80 percent compared with flood-damage levels in the future without action.

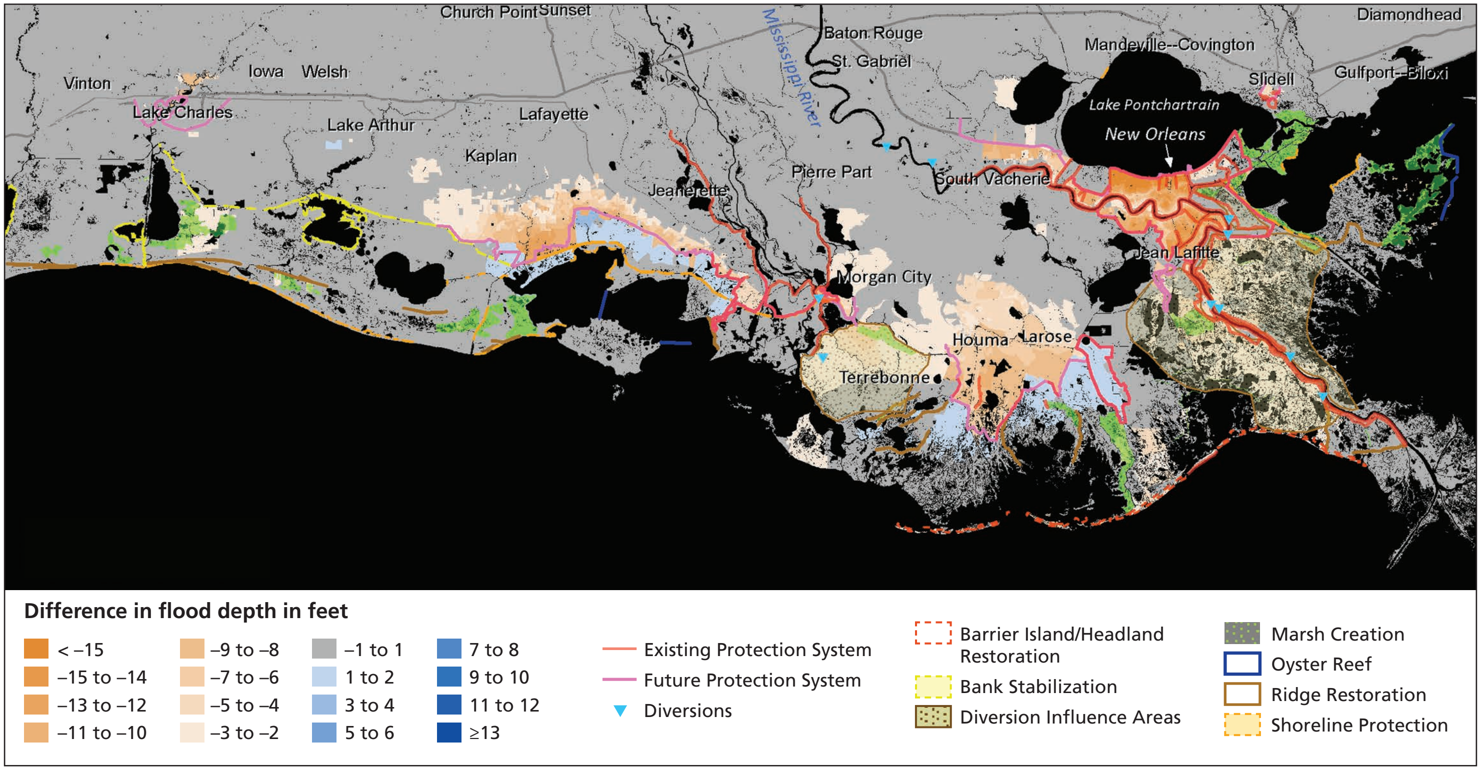
Figure S.3 shows CLARA results coast-wide for how the portfolio of projects included in the Master Plan can help to reduce flood damage. The projects associated with the Master

Figure S.2
Reduction in Coast-Wide EAD With and Without the Master Plan



SOURCE: Groves, Fischbach, Knopman, et al., 2013.
NOTE: EAD represents the average damage projected to occur from a storm surge flooding event from a Category 3 or greater storm in any given year, taking into account both the projected damage and the overall chance of such a storm occurring.
RAND *RR437-S.2*

Figure S.3
Reduction in 100-Year Flood Depths in 50 Years Due to the Master Plan (Less Optimistic Scenario)



SOURCE: Fischbach et al., 2012a, Figure 10.6.
NOTE: The 100-year flood is the flood depth that has a 1-percent chance of occurring in any year.
RAND *RR437-S.3*

Plan are indicated on the map, and include structural protection (in pink), river diversions to rebuild wetlands, and other coastal restoration projects. Areas marked in blue on the map face deeper levels of flooding; areas marked in orange face less flooding.

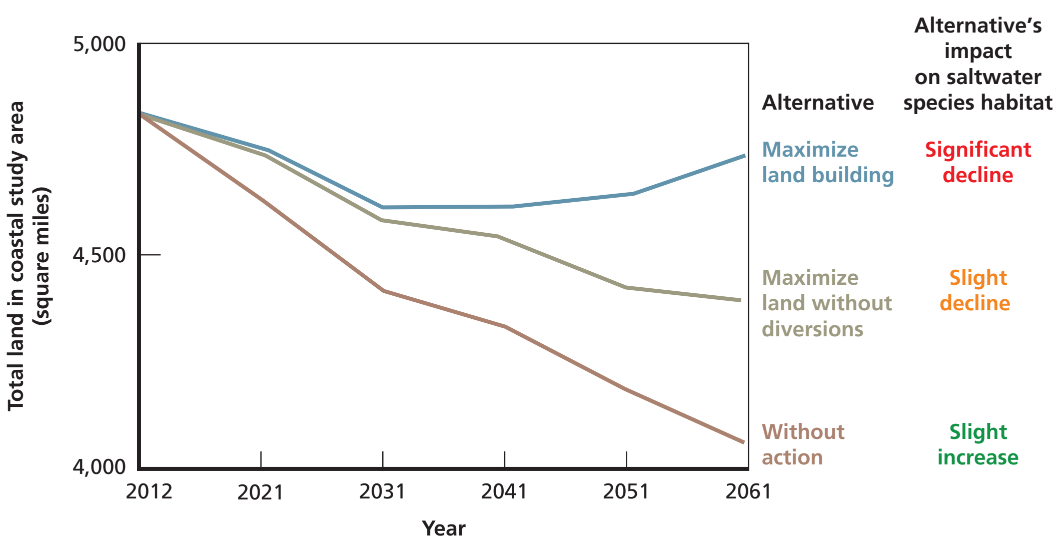
Using a Planning Tool to Compare Protection and Restoration Projects and Develop a Comprehensive Plan

One of the key benefits of Louisiana's Master Plan approach is the use of objective, scientific information, such as the results generated from the systems models (e.g., CLARA), within a quantitative framework that enables the development and comparison of different strategies and supports deliberations among them. Interactive visualizations are useful to ensure that decisionmakers understand the key trade-offs among strategies.

For example, because land building is an important goal, the Planning Tool identified a series of sediment diversion, marsh creation, and other restoration projects that are likely to lead to the most land building over the 50-year planning horizon. This alternative includes several large sediment-diversion projects. But policymakers face other decision criteria beyond maximizing land building. One key criterion is preserving habitat for different species of aquatic life in the Gulf, and large sediment diversions can affect that habitat. This is because such projects, which are very effective at building land in the long term, also decrease the salinity of shallow wetlands where many aquatic species spend a portion of their lives.

This trade-off is reflected in Figure S.4, which shows changes in land in square miles from 2012 to 2061, along with the likely effects on habitats of saltwater aquatic species. The "without action" alternative results in the significant loss of about 700 square miles and shows a slight increase in the saltwater species' habitat. Conversely, the "maximize land building" alternative leads to stabilization of coast-wide land area over time but would lead to a significant decline in

Figure S.4
Trade-Offs Between Land Building and Area of Suitable Saltwater Habitat



SOURCE: Groves, Fischbach, Knopman, et al., 2013.
RAND *RR437-S.4*

the saltwater species' habitat. The Planning Tool also created another alternative: "maximize land without diversions." Although this alternative leads to only a slight decline in the saltwater species' habitat, it would not achieve the state's objective of stabilizing the coast-wide land area. This trade-off analysis led the state to consider additional alternatives (not shown here) in which sediment diversions were used (sparingly) to strike the right balance between land building and support for all aquatic habitats.

The Planning Tool does not tell policymakers *which* alternative to choose. Rather, it allows them to visualize what the trade-offs are in choosing one alternative over another. In deciding on the Master Plan, policymakers actually needed to understand the implications of trying to balance multiple decision criteria (not just saltwater species' habitat) relative to the ultimate goal of the sustainability of the landscape.

How Louisiana's Experience Can Inform Coastal Resilience Planning Elsewhere

This work provides a successful example of how integrated, objective, analysis-based planning can address pressing coastal challenges. By using this analytic approach, CPRA was able to develop a $50 billion, 50-year Master Plan. The planning processes helped CPRA and stakeholders grapple with tough trade-offs between "hard" (infrastructure) and "soft" (restoration and nonstructural mitigation) approaches to coastal resilience and sustainability. Concurrently, it helped CPRA consider how different future scenarios would affect the success of different approaches.

The resulting Master Plan is the first comprehensive solution for Louisiana's coast to receive broad support from the Louisiana public and the many agencies—federal, state, and local—engaged in protecting the Gulf Coast. It passed the Louisiana legislature unanimously in May 2012 and is currently being implemented. And, with the analytic infrastructure in place, this approach will also help as CPRA takes steps to secure long-term funding, refine its near-term implementation strategy, and adapt the Master Plan over time as assumptions change.

Coastal Louisiana is only one of many areas of the nation dealing with such challenges. In just the last decade, coastal storms such as hurricanes Ivan (2004), Charley (2004), Katrina (2005), Rita (2005), Gustav (2008), Ike (2008), Isaac (2012), and Sandy (2012) have changed lives and economies along U.S. coastlines.

The Mid-Atlantic States—following Hurricane Sandy—and other coastal regions are facing challenges in planning similar to those faced by Louisiana. In each of these regions

- coastal risks are increasing, but in uncertain ways
- there are many different types of strategies to consider to reduce risks and restore coastal landscapes
- solutions will be implemented by local, regional, state, and federal agencies.

Given the uncertainty of how these factors—alone or in combination—will play out in a given region, coastal regions and communities are in need of a new approach to developing coastal resilience plans with actionable strategies. Our work in Louisiana and elsewhere suggests that the approach should be based on three principles:

- Public participation is essential throughout the planning process to understand the preferences and local knowledge relevant to the decisions and to ensure credibility and legitimacy of the technical analysis.
- Technical analysis is meant to inform deliberations and value judgments by decisionmakers rather than provide a single answer that is then "sold" to affected constituencies.
- A successful and sustainable long-term strategy must be robust and adaptive—one which includes near-term investments that are shown to provide a strong foundation for future decisions that would be made in response to conditions that are revealed over time.

The application of this approach and these principles can help that region assimilate different goals or points of view and disparate and potentially conflicting technical analyses into a framework to identify a robust strategy for recovery and future risk reduction. Other coastal areas could also benefit from the application of this approach, including the Eastern Seaboard, as it seeks to be better prepared for sea-level rise and future storms, and California, as it seeks to address its vulnerability to sea-level rise and other threats to its Sacramento–San Joaquin River Delta.